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ACCRETIONARY ORIGIN FOR THE LATE ARCHEAN ASHUANIPI COMPLEX OF CANADA;

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At 300 x 300 km, the Ashuanipi complex is one of the largest massif granulite terranes of the Canadian Shield (Fig. 1). It makes up the eastern end of the 2000-km-long, lower-grade, east-west belts of the Archean Superior Province (1), permitting lithological, age and tectonic correlation (2). Numerous lithological, geochemical and metamorphic similarities to south Indian granulites suggest common processes and invite comparison of tectonic evolution.

Superior Province consists of a northern high-grade region, the Minto block (Fig. 1), and the well-known southern subprovinces of 3.1-2.7 Ga greenstone-granite, metasedimentary gneiss and plutonic character (1). Metasedimentary gneiss probably extends, through poorly-known territory, from the east-striking belts into the Ashuanipi complex (1,3).

Several gneissic and homogeneous lithological units are recognized on the regional scale in the Schefferville area (3,4). Paragneiss, consisting of assemblages of Grt-Opx-Bio-Plg-Qtz±Kfs, is the oldest. Although mainly psammitic, it has rare compositional variation to pelite and leptynite. Interlayered with paragneiss on the m to km scale is early tonalite, with characteristic igneous oikocrystic orthopyroxene (5), variably broken down to biotite and metamorphic orthopyroxene during deformation and migmatization. It varies compositionally to rare diorite and gabbro. Layered pyroxenite-peridotite sills, up to 80 m thick, with rare associated gabbro, occur as strings of boudinaged pods up to 10's of km long.

Homogeneous intrusions make up some 90% of the terrane. The oldest bodies are foliated Opx-Bio±Cpx±Hbl tonalite, quartz diorite and diorite. These are cut by the most abundant rock type of the complex: coarse-grained to megacrystic Grt-Opx-Bio-Plg-Qtz-Kfs granodiorite, mapped as homogeneous diatexite (3,4,6) because of its association with, and compositional similarity to paragneiss. Two texturally similar units are recognized: an older, more voluminous, garnet-bearing variety, and younger pods, layers and plutons without garnet. Massive to weakly foliated Cpx-bearing granite and syenite, locally with nepheline, form the youngest intrusions.

The dominant structural elements are an $S_1$ migmatitic layering in gneisses and foliation in homogeneous intrusions that defines a NE-dipping homocline on the regional scale. Open, upright $F_2$ folds of $S_1$ layering form discontinuous, east-plunging or doubly-plunging structures, generally basins, on the 10-20 km scale. The folds are localized in large-scale, open "Z" warps of regional foliation, possibly related to dextral transcurrent movement. Narrow concordant shear zones are accompanied by abundant migmatitic leucosome, Grt, Opx-bearing pegmatite, and late, brittle fractures. Diatexite contains inclusions of migmatitic ($S_1$) gneiss, but some concordant bodies are folded with gneiss in $F_2$ structures, bracketing intrusion between $D_1$ and $D_2$.

The assemblage Grt-Opx-Bio-Plg-Qtz-Kfs is ubiquitous in the Schefferville region, in paragneiss, diatexite, some early tonalites, and in late pegmatites. One occurrence of Grt-Crd-Sil-Bio-Plg-Qtz-Kfs has been recognized. Mafic rocks have Opx-Cpx-Hbl-Plg±Qtz. Two generations of orthopyroxene are present locally in early tonalite: igneous oikocrysts and blocky, metamorphic porphyroblasts surrounded by mafic depletion haloes. Minerals are fresh and yield Grt-Bio temperatures for paragneiss and diatexite in the 750-800°C range using (7). Based on Grt-Opx-Plg-Qtz barometers (8,9), metamorphic pressure was in the 5 to 6.5 kb range. Whole-rock geochemical analyses of migmatitic rocks show no evidence of Rb depletion with respect to K (avg K/Rb ratio of 210). Patchy retrogression of Opx and Grt to Bio is common in the western part of the complex (10,2).

Diatexites are uniformly coarse-grained, have sharp, concordant contacts with adjacent gneiss, and contain angular to lenticular gneissic inclusions, suggesting intrusive emplacement into gneiss at the present structural level. Garnet-bearing diatexite is very similar to paragneiss in terms of mineralogy, mineral chemistry, major, trace and rare-earth element chemistry (Fig. 2) and may thus represent the fused equivalent of paragneiss. REE abundances and patterns are comparable for early tonalite, paragneiss and diatexite. Tonalites and diatexites have higher K/Rb ratios than gneisses (290, 257 respectively), possibly indicating igneous fractionation (11).

Zircon and monazite U-Pb ages (2) constrain the plutonic and metamorphic history. Early tonalites have discordant zircons with minimum ages greater than 2.7 Ga whereas a foliated tonalite pluton is 2.69 Ga. Diatexites have some inherited zircon; igneous grains give 2.67-2.66 Ga. Monazite from late pegmatite is 2.65 Ga, similar to the regional monazite cooling ages in gneiss and diatexite. A zircon date of 2.642 Ga on retrogressed diatexite, distinctly younger than monazite cooling ages, suggests that a discrete, late, localized hydrothermal event caused the retrogression (2). The small age gap between zircon and monazite ages indicates that cooling began quickly after the metamorphic peak. Proterozoic sediments of 2.15 Ga age overly the granulites unconformably, supporting this inference.

Critical parameters to consider in interpreting the origin of the complex include: 1) supracrustal rocks are paragneiss, derived from homogeneous, immature clastic metasediments; 2) most of the complex is made up of intrusive rocks, dominantly diatexite, generated, emplaced and crystallized during the high-grade metamorphism, at 2.67-2.66 Ga, at the same time as granite plutonism in along-strike low-grade belts to the west (12); 3) metamorphic pressures are moderate to low for granulites (17-22 km erosion level); cooling and erosion began quickly after metamorphism; 4) melting was the dominant process during granulite metamorphism, producing migmatitic textures in gneiss and generating diatexite melts at depth.

Based on observations at the 17-22 km erosion level in the Ashuanipi complex and 8-15 km levels exposed in belts to the west, a model of metamorphic development in a >2000 km accretionary prism is proposed (Fig. 3): immature sediments derived from adjacent arcs (greenstone belts) were accreted and thickened to a maximum 55 km (13) at 2.75-2.70 Ga. Thermal relaxation and/or arc magmas (14) heated the lowermost crust, causing fusion and upward heat transfer through granitic magmatism. Magmas crystallized as deep-crustal charnockites (diatexite) and fractionated (15) to form higher-level peraluminous granite (12). The overthickened crust rebounded to an isostatically stable 35 km by erosionally removing the upper 8-22 km. Post-metamorphic erosion-level differences along the belt may be related to the amount of early structural thickening. Similar features characterize some Cenozoic accretionary complexes in the N. American Cordillera (14,16).

Diatexite, which forms the bulk of the Ashuanipi complex (17), is similar to S. Indian "Ponmudi-type"(18) charnockite in terms of texture, mineralogy, composition and crystallization conditions, but probably crystallized to granulite-facies assemblages directly from a melt. Before comparing models of tectonic evolution, the age of Indian charnockitization with respect to regional metamorphism, plutonism and crustal formation should be documented by precise U-Pb studies.

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Fig. 1: Superior Province (1) showing Ashuanipi complex in relation to E-W subprovinces.

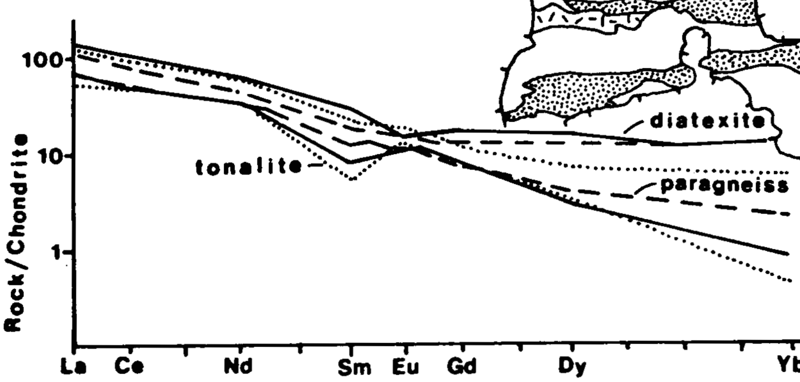


Fig.2: Chondrite-normalized REE patterns showing similarity among major rock types.

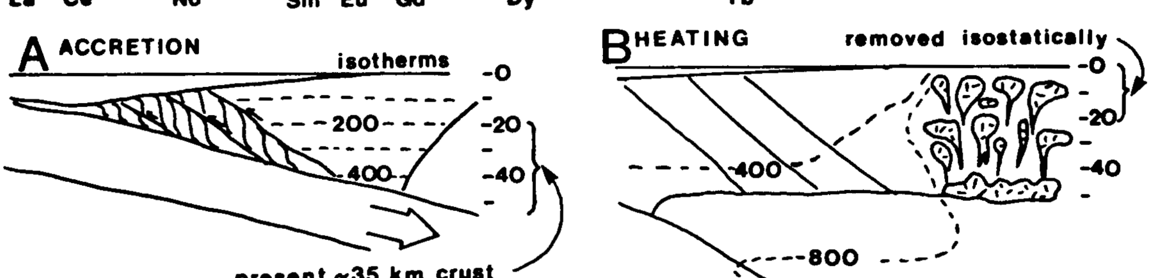


Fig.3: Accretionary model for (A) construction of a 55-km thick sedimentary crust, later heated (B), fused and thinned by erosion.